White light interferometric profiling of ultra-thin foil high power laser targets

C. Spindloe and H. F. Lowe
Central Laser Facility, STFC, Rutherford Appleton Laboratory, HSIC, Didcot, Oxfordshire, OX11 0QX, UK

Main contact email address **C.Spindloe@rl.ac.uk**

Abstract
Using the Wyko NT9300 optical profiler of the Target Fabrication Group ultra-thin foil aluminium, plastic (parylene-N) and carbon laser targets were characterised for flatness to sub-nm precision. The foils were characterised using 2D and 3D surface topography measurements over the range 0.1 nm to 10 mm. This data gave valuable information that was used by experimental groups and also provided valuable insight into fabrication processes and procedures enabling the production of higher quality targets.

Foil holders (with clear through holes of diameters in the range 500 µm – 1.2 mm) were mass produced using established techniques; mainly chemical etching of sheet material but some holders were micro machined. The target holders were used to support (ultra-)thin films prepared in the Target Fabrication Laboratory. The films ranged from 25 nm to 500 nm in thickness and were floated onto the mounts from a water surface and then flattened manually using a combination of local drying and stretching and in the case of plastic foil heat shrinking. Ultra-thin foils require great care in their handling due to their very low mechanical strength.

Aluminium Foils
First trials on aluminium float-off foils presented a difficulty in preparing "mirror-finish" foils as evinced by a low yield rate. Profilometry data showed large-scale surface waviness in the foils: the aluminium float-off foils when characterised in a 2D image and x-y line out (see figure 1) showed typical 3 µm waviness in x but this was much overshadowed by the typical 10µm waviness in the y direction. The foil waviness often increased within a few minutes of the foil being mounted indicating that a combination of drying mechanisms in combination with the surface topology of the copper foil target holder might be responsible for the flatness issues. Close examination of the mount surface revealed quasi-parallel surface grooves (which were an artefact of the original copper sheet production process further increased in size by some stages in the etch processing). It was postulated that the capillary action of the residual float water along the channels formed by the grooves and mounted foil caused the foil to be ridged in a direction perpendicular to the surface channels. To test this hypothesis mounts were used with the channels rotated by 90° and in these cases the creases in the foil rotated by approximately 90°.

Figure 2 is a 3D image showing both the groove structures (beneath the mounted foil) on the copper support surface and the (typically irregular) rippling of the mounted aluminium foil.

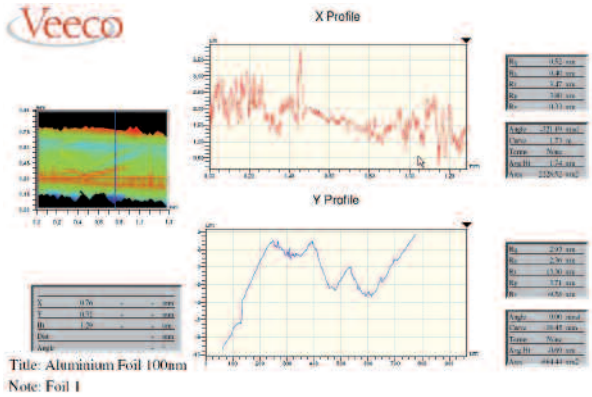


Figure 1. Surface waviness data of a 50 nm aluminium float-off foil.

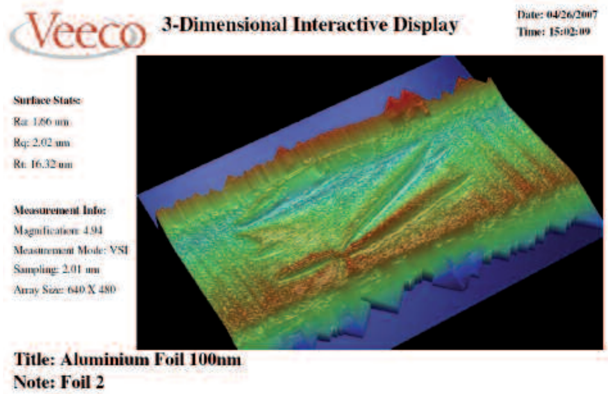
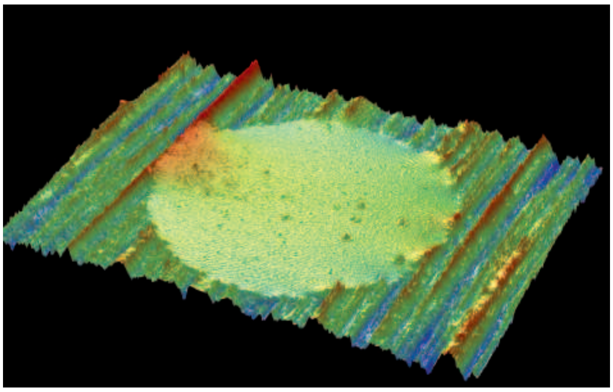


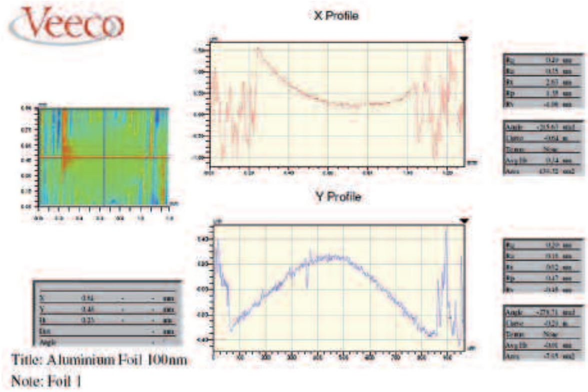
Figure 2. 3D Image of the mounted aluminium foil with the copper channels visible (through foil).

Production Modifications – Aluminium Foils
By using a combination of manual foil stretching and drying techniques it was possible to produce thin foils having a "mirror finish". Examples of mounted "mirror finish" ultra-thin aluminium foils are shown in figures 3 and 4.

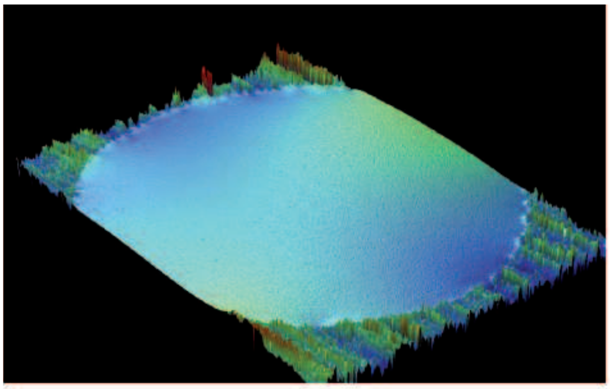
However, the failure rate for mounting foils directly onto copper mounts was almost 90%. It was found that by applying a thin glue layer around the perimeter of the mounting hole (and thereby eliminating the effect of the channels in the copper surface) the failure rate was reduced to approximately 30%.

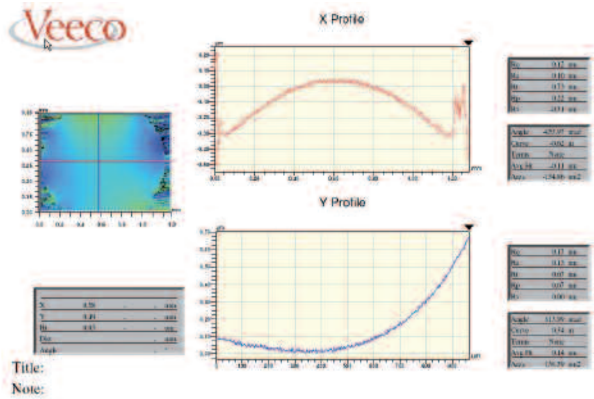
Plastic (Parylene-N) Foils
Parylene-N foils contract under the action of heated air currents from either a hot air blower or a hot plate. With





Figures 3 & 4. Mirror finish foils with waviness typically less than a micron.





Figures 5 & 6. Mirror finish plastic (parylene-N) foils.

practice it was possible to use the action of heat to tension mounted plastic foils to a "mirror finish" overcoming the rippling effect caused by capillary action of residual float-off water. (Heating was used in combination with manual stretching and drying techniques.) Examples of mounted "mirror finish" ultra-thin parylene-N foils are shown in figures 5 and 6. In the case of parylene-N foils it was not necessary to use a layer of glue around the perimeter of the mount hole; the tensioning effect of heat was sufficient to overcome structure imposed by surface features on the mount.

Carbon Foils

There was a requirement for foils of 2.5 nm thick carbon to be prepared. These foils could be floated onto water with great difficulty and were extremely fragile. They could only be supported by a thin copper mesh (rather than over an open hole of typically 800 μm diameter). Trials were carried out to optimize line spacing and a 100 LPI mesh was shown to be best for the support.

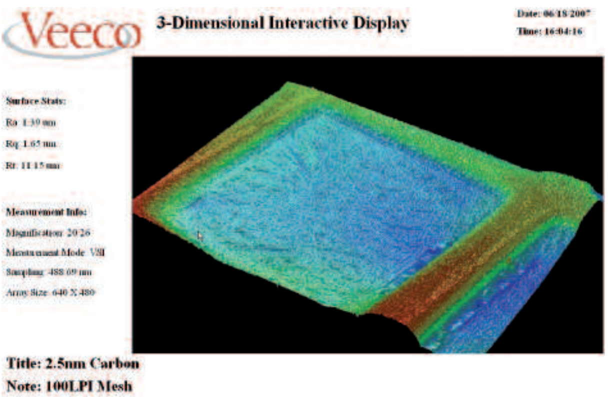


Figure 7. A 2.5 nm thick carbon foil floated onto a 100 LPI (copper) mesh.

Figure 7 shows a 3D image of a mounted 2.5 nm thick carbon foil exhibiting a surface roughness of less than a micron between the supports. The rate for survival of ultra-thin carbon foil targets was approximately 5% due to the extreme fragility of the films.

Conclusions

Although the production of ultra-thin aluminium "mirror-finish" foils is possible, the process is time consuming and needs refining to be viable for mass production. The production of ultra-thin plastic (parylene-N) foils is much more suited to mass production having an acceptably low failure rate and producing much flatter foils.

Using glue to negate the effect of the capillary action in the channels of the mounts or using mounts made by other processes to avoid the etched channels significantly increases the success rate of aluminium foil preparation.

For ultra-thin foils (of carbon) a mesh is required to support the foil and this limits the free-standing foil to a relatively small area of a 200 μm side square.